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The structural colour and behaviour of the gemmy insects above the pond and canopy

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In mammals, the melanopsin gene (*Opn4*) encodes a sensory photopigment that underpins newly discovered inner retinal photoreceptors. Since its discovery in *Xenopus* and subsequent description in humans and mice, melanopsin genes have been described in all vertebrate classes. Initially, all these sequences have been considered to represent a single orthologous gene. We recently described the discovery and functional characterisation of a new melanopsin gene in fish, bird and amphibian genomes. Based on sequence, chromosomal localisation and phylogeny we identify our new melanopsins as the true orthologues of the melanopsin gene previously described in mammals and term this grouping *Opn4m*. By contrast, the previously published melanopsin genes in non-mammalian vertebrates represent a separate branch of the melanopsin family termed *Opn4x*. RT-PCR analysis in chicken, zebrafish and *Xenopus* identifies expression of both *Opn4m* and *Opn4x* in tissues known to be photosensitive. In the chicken retina, *Opn4m* mRNA is found in a subset of cells in the ONL, INL and ganglion cell layers, the vast majority of which also express *Opn4x*. Importantly, we have shown that a representative of the new melanopsins (*Opn4m*) encodes a photosensory pigment capable of activating G-protein signalling cascades in a light- and retinaldehyde-dependent manner under heterologous expression. These data raise important questions regarding the functional differences between *Opn4x* and *Opn4m*, the associated adaptive advantages for most vertebrate species in retaining both melanopsins, and the implications for mammalian biology of lacking *Opn4x*.

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34.4. G11-mediated pineal phototransduction for entrainment of the pineal clock

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In a variety of nonmammalian vertebrates, the pineal gland is the primary extraretinal photosensitive tissue and plays a major role in regulation of the circadian physiology. As the first example of extraretinal opsin, we found pinopsin expression in the chicken pineal gland in 1992. Pinopsin-mediated light signaling was investigated by searching for G-protein(s) coupled with the pineal photoreceptors. G11- α and Gt- α were cloned from the pineal gland and immunocytochemical analysis colocalized these G-proteins with pinopsin. When a Gq/11-coupled receptor was expressed ectopically in cultured pineal cells, non-photic pharmacological activation of endogenous G11 induced phase-dependent phase shifts of the melatonin rhythm in a manner very similar to the effect of light. These results together demonstrate that G11-mediated pathway

contributes to the photic entrainment of the circadian clock. In addition to pinopsin, melanopsin expression is also detected in the pineal gland. It is conceivable that either or both of these photoreceptors trigger light-dependent activation of G11 responsible for entrainment of the pineal clock.

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34.5. The structural colour and behaviour of the gemmy insects above the pond and canopy

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Damselflies, *Calopteryx japonica*, possess three types of colour polymorphism in their wings. Immature and matured females have the same grayish drab wing, gynochrome, whereas male wing colouration changed depending on its mature level. The matured male possesses bright blue–green colour, androchrome, whereas the immature male resembles the gynochromic colour. Those colours of males are produced by the structure of the multilayer in the wing vein, whereas there was a big difference in the transmittance between mature and immature males' wing. We presented the four different perched, tethered models against the territorial matured male. The male attacked against the matured male model, and showed the display of reproduction behaviour against the matured female model. When the wing of the matured male was covered with the grey spray, the aggressive behaviour of territorial male had completely disappeared. The territorial male attacked against the female model which covered with the bright blue–green particles mimicking the matured male. The coloration of jewel beetle, *Chrysochroa fulgidissima*, is also produced by the layered nanostructures of the epicuticle. No apparent colour differences in sex were observed. When we placed several models on the canopy, the model which was made by the real elytron could only attract the mate. The behavioural experiments revealed that green elytra with dark red–purplish stripes have a signaling function in mate recognition. Those results indicate that the structural colour of those insects plays a significant role in their optical signaling of intraspecies.

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34.P1. Pigmented retinal cells from *Chasmagnathus granulatus* respond directly to pigment-dispersing hormone β -PDH

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